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Western Black-Headed Budworm and Hemlock Sawfly In Alaska
Historical Summary and Bibliography

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WESTERN BLACK-HEADED BUDWORM AND HEMLOCK SAWFLY IN ALASKA HISTORICAL SUMMARY AND BIBLIOGRAPHY

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Western Black-Headed Budworm and Hemlock Sawfly in Alaska

INTRODUCTION

Western black-headed budworm, *Acleris gloverana* (Wlshm.) (formerly *A. variana* (Fern.), Powell 1962) and hemlock sawfly, *Neodiprion tsugae*, (Midd.) have historically been the most destructive defoliators of Southeast Alaska's coastal forests. Recurrent infestations of these insects have been recorded there since the early 1900's. Black-headed budworm is found primarily in Southeast Alaska, but has been noted periodically in the areas of Prince William Sound and southwest Alaska. Hemlock sawfly occurs throughout the coastal forests of Southeast Alaska, but has typically been more prevalent south of Frederick Sound (see map, Fig. 1).

Black-headed budworm defoliates western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), Sitka spruce (*Picea sitchensis* (Bong.) Carr.), and rarely, white spruce (*P. glauca* (Moench) Voss), while hemlock sawfly defoliates primarily western hemlock. Defoliation by either insect can cause reduced tree growth and top-kill. Tree mortality is uncommon during outbreaks of either insect species alone, but due to their feeding habits, it is more likely where the two species are feeding simultaneously. Black-headed budworm larvae normally limit their feeding to new growth (current year's buds and elongating shoots), while hemlock sawfly larvae consume older foliage. Appendix A includes a detailed description of the biology of the black-headed budworm and the hemlock sawfly.

Both black-headed budworm and hemlock sawfly populations have been cyclic, subject to sudden growth and decline. Due inpart to this cyclic nature, no full-scale suppression projects have been conducted in Alaska against either insect species. However, a pilot project and a small field test were conducted in Southeast Alaska during the 1960's to test the effectiveness of DDT (Anon. 1963) and *Bacillus thuringiensis* (Schmiege and Hard 1966d) against the black-headed budworm. Studies of biotic control factors of black-headed budworm and hemlock sawfly have identified their major parasites and predators (McCambridge 1953; Torgersen 1968, 1969a, 1969b and 1970; and Hard 1976a). Likewise, the impact of abiotic control factors, particularly weather, have been documented (McCambridge 1955c; Downing 1961; Anon. 1962c; Rose 1962; Schmiege 1966b; Werner 1969c; and Hard 1974a).

Historically, some timber salvage has been conducted on manageable sites most heavily damaged by the black-headed budworm and the hemlock sawfly. Future evaluations will include assessment of the impact of these defoliators on the vast areas of young-growth timber now present across Southeast Alaska.

The following information is an historical summary of black-headed budworm and hemlock sawfly activity in Alaska. Descriptions vary, based on available information.

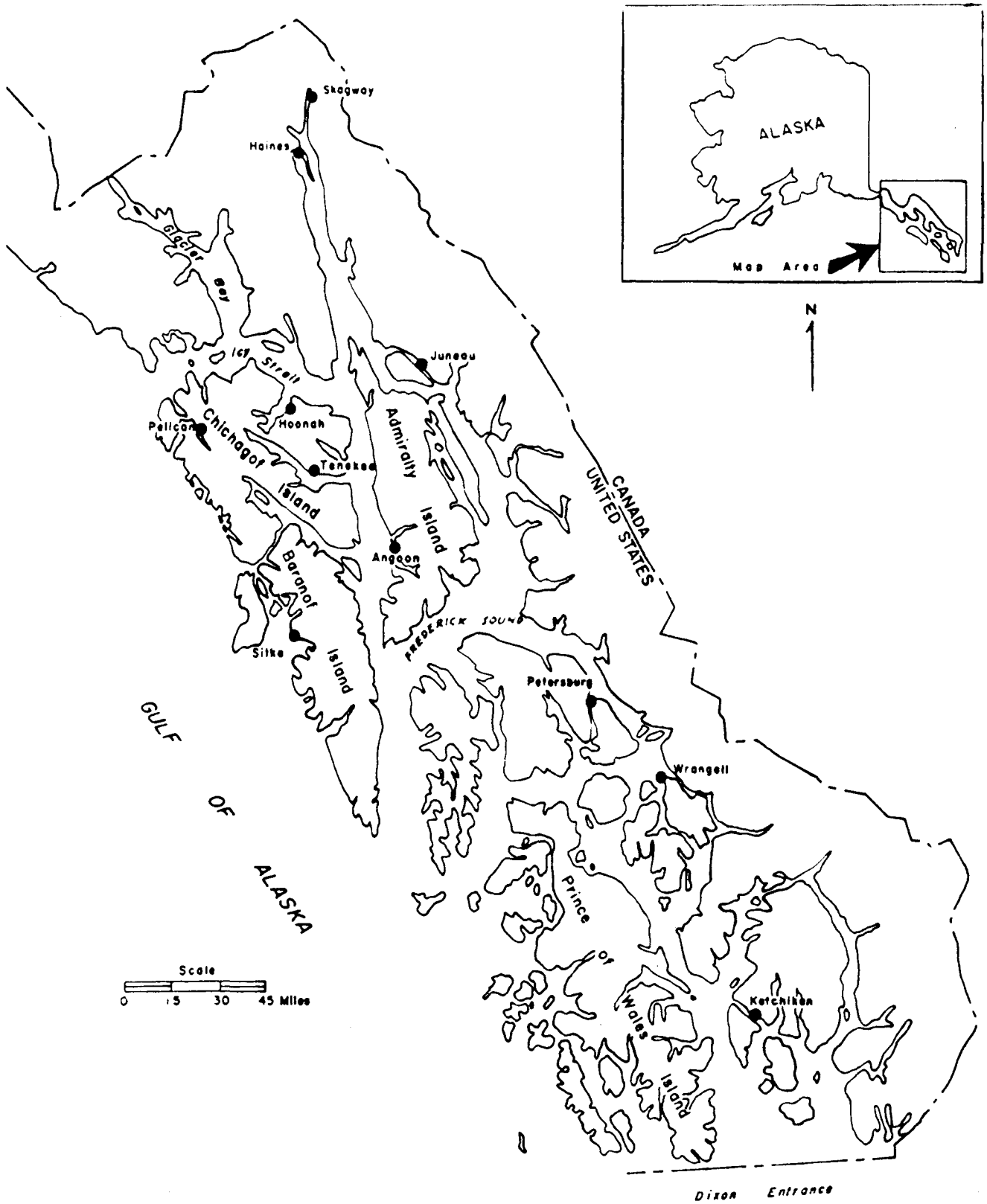

Figure 1. Map of Southeast Alaska.

The attached Bibliography includes the majority of publications and other documents pertinent to the history of black-headed budworm and hemlock sawfly in Alaska.

HISTORICAL SUMMARY

Black-headed Budworm and Hemlock Sawfly in Alaska

1917 Small area near Wrangell, AK was defoliated by unknown insect (Flory 1920).

1918 Asher Ireland, Forest Ranger from Petersburg, reported defoliation of western hemlock and Sitka spruce by unidentified insects along several hundred miles of shoreline between Juneau and Petersburg (Ireland 1918).

1919 Defoliation of hemlock by unknown insect was reported south of Wrangell. Several damaging insects were collected during field investigations on the Tongass and were identified as sawfly and moth larvae (Jaenicke 1919).

1920 Superintendent of Alaskan Forests reported that almost all of the hemlock on the Tongass south of Wrangell Narrows had been impacted by defoliation (Flory 1920). Sawflies (Genus *Neodiprion*) were identified from specimens collected at Carroll Inlet and Thorne Arm (Ames 1920). Black-headed budworm (Genus *Peronea*, family Tortricidae) was tenatively identified from specimens collected on the Tongass (Jaenicke 1920).

1925 Black-headed budworm was identified from insect specimens collected on the Chugach National Forest (Heintzleman 1939).

1932 Areas near Cape Bendell (NW tip of Kupreanof Is.) and Clover Pass (Revillagigedo Is. near Ketchikan) were defoliated by sawflies. A sample plot was established to monitor the hemlock sawfly infestation at Mitchell Bay (west-central Admiralty Is. near Angoon; Taylor 1932).

1936 The sample plot at Mitchell Bay was remeasured. Very little mortality had occurred, though top-kill was noted on several hemlocks. Hemlock sawfly infestation had subsided since 1932 (Forward 1936).

1939 No evidence of defoliation by budworm or sawfly was detected on the Tongass National Forest (Heintzleman 1939).

1946 Defoliation by black-headed budworm and hemlock sawfly was observed at Peril Strait (Heintzleman and Furniss 1946).

1948 Moderate to heavy defoliation by the hemlock sawfly was noted on parts of the Petersburg and Southern Divisions of the Tongass National Forest (Furniss 1950), in particular, at Edna Bay and on St. John's Island (Armstrong 1948). Outbreaks appeared to be declining. A small infestation of black-headed budworm was observed at the mouth of Anan Creek, southeast of Wrangell (Furniss 1951).

1950 Black-headed budworm infestation was evident at various locations on Prince of Wales Island.

1951 Considerable defoliation was mapped from El Capitan Pass to Chomondeley Sound on Prince of Wales Island and in the Gedney Pass area of Revillagigedo Island (Jones 1951). Defoliation was likewise located from Petersburg to the southeastern end of Etolin Island and east to the mainland (Anderson 1951). The black-headed budworm infestation of 1951 was believed to extend from Portland Canal northwestward to the northern end of Kupreanof Island.

1952 An annual survey program for evaluating forest insect conditions in Alaska was initiated (McCambridge 1952). An extensive aerial survey of the southern Tongass was completed including collections of samples and host data at 26 different sites. Black-headed budworm activity extended across approximately 11,640,000 acres of the Tongass National Forest. Western hemlock was the primary host with occassional damage found on Sitka spruce (moderate defoliation of young spruce noted at Petersburg and Juneau) and mountain hemlock. Heavy to very heavy defoliation of western hemlock was present from Portland Canal to the northwest shore of Kupreanof Island (approximately 8,040,000 acres). Tree mortality was rare, but top-kill was common throughout the area. Light to moderate defoliation extended over approximately 3,600,000 acres between Frederick Sound and Berners Bay. Pilots flying as high as 4000 feet reported large numbers of "bugs" (later found to be budworm moths) hitting their windshields. Based on egg counts, budworm populations in areas of heavy defoliation were expected to decline in 1953.

Black-headed budworm and hemlock sawfly in combination caused defoliation in the Polk and McKenzie Inlet areas on Prince of Wales Island (McCambridge 1952). Light populations of hemlock sawfly were measured at various locations from Admiralty Lakes south to Ketchikan.

1953 The black-headed budworm outbreak extended over almost all of the Tongass National Forest (McCambridge 1953). The only uninfested area was the narrow band of hemlock facing the Gulf of Alaska from the southern end of Baranof Island to the southern end of Prince of Wales Island (see Fig. 2). Top-kill as high as 50 percent of the total crown length of hemlock was measured in areas of heaviest defoliation (approximately 6600 acres forestwide). South of Frederick Sound, budworm populations appeared to be subsiding and defoliation was lighter than that of 1952. North of Frederick Sound, budworm populations were higher than those

(1953 continued)
reported in 1952 and defoliation was subsequently more severe. Areas of heaviest defoliation north of Frederick Sound covered approximately 1,500,000 acres.

Hemlock sawfly damage was evident along the east side of Prince of Wales Island for the third consecutive year and appeared to have increased its range, causing damage between Ketchikan and Petersburg (scattered patches of defoliation across approximately 4,000,000 acres, see map, Fig. 2.) No direct control program was recommended against either black-headed budworm or hemlock sawfly, however, pilot testing of DDT aerial sprays was suggested (McCambridge 1953).

1954 The black-headed budworm epidemic continued on the Tongass National Forest north of Frederick Sound and within Glacier National Park (McCambridge 1954c). The area of active infestation included approximately 6,740,000 acres (400,000 acres within Glacier Bay National Park) . Areas of heaviest defoliation occurred along Lynn Canal and Icy Strait. Scattered areas of moderate to heavy defoliation were located on Chichagof and Admiralty Islands and along the west side of Baranof Island. In general, defoliation in 1954 was lighter than that of 1953. The infestation south of Frederick Sound and in the Yakutat area had subsided by 1954. Egg counts indicated that the budworm outbreak would probably not continue in 1955.

The hemlock sawfly outbreak on the southern Tongass ceased (McCambridge 1954c). Sawflies were still found throughout the Tongass, but populations appeared endemic. Light hemlock defoliation by sawflies was noted in the vicinity of Excursion Inlet (east of Gustavus, AK).

1955 Budworm infestation continued to decline and covered approximately 2,720,000 acres, primarily on the northern Tongass (McCambridge 1955f). Black-headed budworm defoliation (in association with hemlock sawfly) was most severe at Excursion Inlet and was noted from sea level to timberline. Lighter budworm defoliation was present westward to Glacier Bay and along the northwest portion of Chichagof Island. Budworm also caused visible hemlock defoliation along the Endicott River and spruce defoliation near the headwaters of the Skagway River. Total area of heavy to moderate defoliation totalled approximately 620,000 acres, with light defoliation noted on an additional 2.1 million acres (areas of the old outbreak). Significant tree mortality due to budworm defoliation was documented near Thayer Lake on Admiralty Island and near Orchard Lake on Revillagigedo Island. A cool, wet summer was credited with delaying budworm development on the northern Tongass.

1956 The black-headed budworm epidemic had ended (Downing 1956b). Assessment of the damage of the 1948-1955 epidemic began (Downing 1956a). Hemlock stands containing approximately one-quarter of a billion board feet were defoliated during the 1948-1955 budworm outbreak (Downing 1958b).

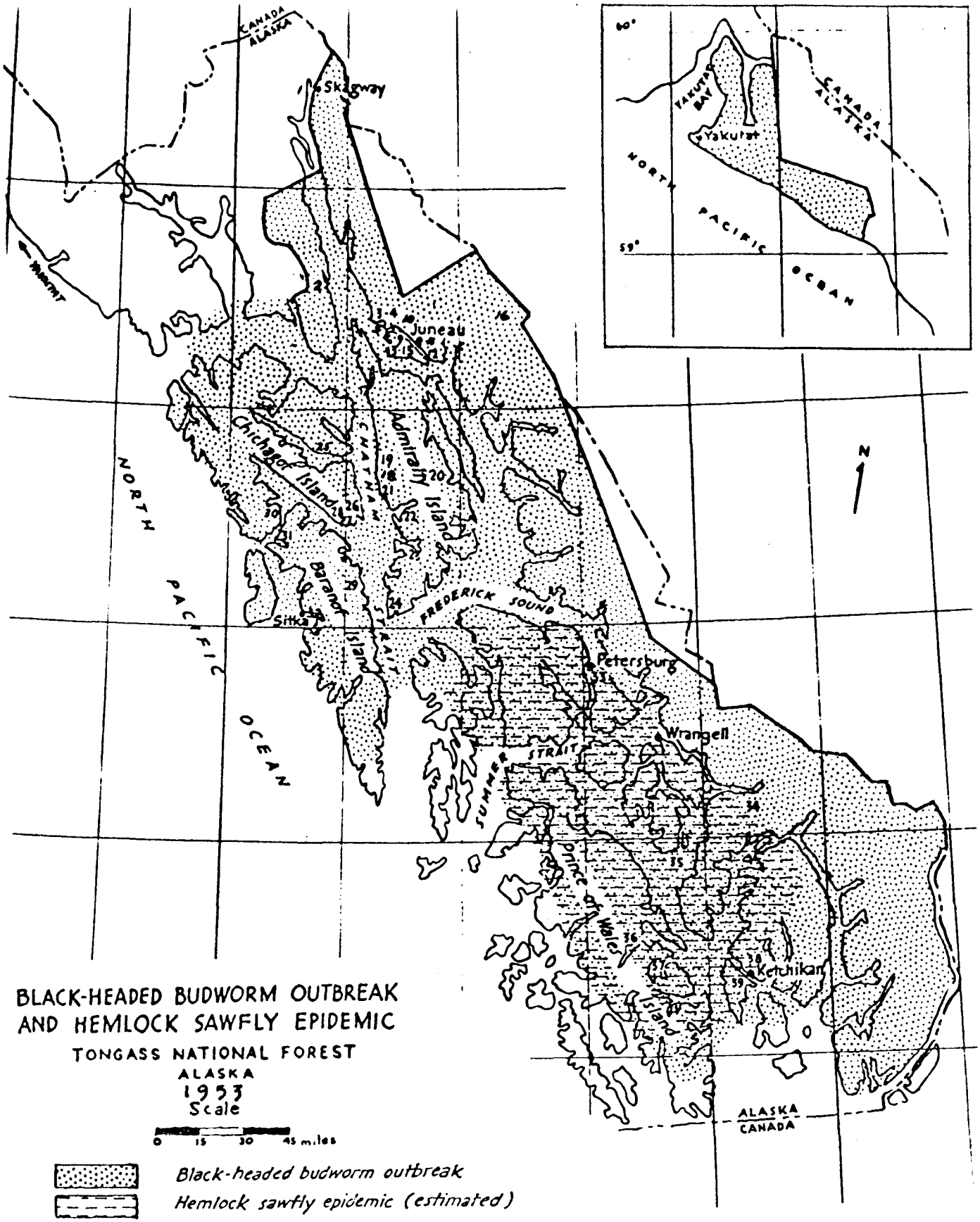

Figure 2. Black-headed budworm and hemlock sawfly activity in Southeast Alaska, 1953 (from McCambridge, 1953).

1957 No significant budworm or hemlock sawfly activity was noted in Southeast Alaska (Anon. 1957).

1958 For the first time in two years, light to moderate defoliation by black-headed budworm was reported near Ketchikan (Downing 1958a). Hemlock sawfly activity occurred in the same area.

1959 A systematic sampling program was started in Southeast Alaska to monitor forest defoliators (Downing 1959a). Highest numbers of budworm were found in the Cholmondeley Sound area of Prince of Wales Island. High budworm populations were also measured around Kasaan Bay and Portland Canal. Budworm and sawfly population increases were predicted for 1960.

1960 Moderate defoliation by budworm was observed in the vicinity of Kasaan Bay (Downing 1960a). All other budworm defoliation was considered so light as to be insignificant. Hemlock sawflies were collected in varying numbers, but were not causing detectable damage. Planning began for a budworm and sawfly pilot control effort (Howard 1960).

1961 Populations of the black-headed budworm south of Frederick Sound appeared to be similar to those of the previous year. (Anon. 1961a). Hemlock sawflies were again collected in insignificant numbers. Prespray studies of the streams in Skowl Arm began.

1962 Large numbers of budworm larvae were collected on Chichagof Island and on the northern portions of Admiralty and Baranof Islands (Crosby 1962). Defoliation (browning) was noticed at several locations on the North Tongass. Most of the South Tongass budworm activity appeared unchanged, with the exception of noticeable defoliation on Dall Island, near Craig, AK (west Prince of Wales Island) and along the west arm of Cholmondeley Sound (Anon. 1962a) . Budworm defoliation on the Tongass totalled approximately 1800 acres. Some individual sawflies were found among collections on the Chugach National Forest, but no significant defoliation was observed (Crosby 1962). Prespray studies of streams in Skowl Arm continued in 1962.

1963. Black-headed budworm caused approximately 8000 acres of defoliation in small patches scattered across Southeast Alaska (Crosby 1963). The majority of the budworm activity was located on northern Prince of Wales Island and on the Northern Tongass. The DDT Pilot project was conducted in Skowl Arm (east side of Prince of Wales Island) and though initial budworm populations were extremely low, results indicated that similar operational projects would be feasible (Anon. 1963). Sawfly populations increased moderately in areas north of Frederick Sound, but egg counts in the fall were insignificant.

1964 Though budworm egg counts in 1963 were low, populations increased significantly. Approximately 48,260 acres were defoliated on the Tongass (Crosby 1964). The greatest increases were reported north of Frederick Sound. Budworm populations near Haines and Sitka were noted as very high. The southern half of Admiralty Island and nearby portions of Chichagof and Baranof Islands had high populations of both budworms and sawflies.

Hemlock sawfly populations also increased in 1964. The greatest numbers were found in the Kasaan Bay area of Prince of Wales Island (Crosby 1964). Sawfly populations were expected to continue growing in 1965.

1965 Both black-headed budworm and hemlock sawfly populations declined significantly. Abnormally high July temperatures and a disease organism were believed to be partially responsible for budworm declines (Crosby 1965).

1966 No visible defoliation was caused by the black-headed budworm in Southeast Alaska (Crosby and Baker 1966). In interior Alaska, insignificant numbers of black-headed budworms were collected from white spruce at various highway locations. Hemlock sawfly populations increased from 1965 and medium to heavy defoliation was observed on Kuiu Island near Rocky Pass and on Kupreanof Island near Kake and Irish Creek. Hemlock sawfly caused approximately 5900 acres of visible defoliation in Southeast Alaska. (Crosby and Baker 1967).

1967 Budworm populations remained low for the third consecutive season. High populations of hemlock sawfly were sampled at numerous locations on the Tongass National Forest. The most severe defoliation by hemlock sawfly was located on Chichagof Island near Todd and Sitkoh Bay (Crosby and Baker 1967). Other areas of sawfly damage included the northwest corner of Kupreanof Island and adjacent Kuiu Island, and the northern and west-central areas of Prince of Wales and adjacent portions of Kosiusko Island (Anon. 1967b).

1968 Black-headed budworm populations were low for the fourth consecutive year, causing little noticeable defoliation. Hemlock sawfly populations were similar, but light sawfly damage was noted on Tuxekan Island, at scattered spots on Prince of Wales Island, on several small islands in Trocadero Bay, and at Coco Harbor on Dall Island (Crosby and Curtis 1968).

1969 No budworm defoliation was observed in Southeast Alaska, but egg counts in areas south of Frederick Sound were significantly higher than those of 1968. Visible defoliation was predicted for that area in 1970 (Crosby and Curtis 1969). Black-headed budworm defoliation was reported for the first time in the Prince

(1969 continued)
William Sound area of south-central Alaska. Three defoliated areas, totalling approximately 29,000 acres, were identified. All three were located on Naked Island, near Eaglek Inlet and Eshamey-Paddy Bay. The defoliation was typically light to moderate, though localized areas of top-kill and mortality did occur. Defoliation was noted on both Sitka spruce and western hemlock. Budworm populations in both defoliated and undefoliated areas were predicted to be high in 1970.

1970 Budworm populations in Southeast Alaska remained low. No appreciable defoliation was observed. Populations that had created significant defoliation in the Prince William Sound area collapsed unexpectedly (Anon. 1970). New defoliation was minimal. Population declines were most likely due to cold, wet weather that occurred during the summer months.

Hemlock sawfly caused defoliation from Etolin Island south to Moira Sound on southeast Prince of Wales Island (Anon. 1970). Defoliation was considered light to moderate, except in the west arm of Cholmondeley Sound, where some top-kill occurred.

1971 Black-headed budworm populations were again at endemic levels. Approximately 50 acres were defoliated at Princess Bay on Revillagigedo Island (Curtis and Swanson 1972). Lack of larval parasitism and favorable weather during oviposition supported predictions of higher populations in 1972. Budworm populations in the Prince William Sound area continued to decline and were predicted to be very low by 1972.

Hemlock sawfly caused scattered defoliation on Prince of Wales Island, primarily in the Cholmondeley and Moira Sound areas (Curtis and Swanson 1972). A multi-year infestation on the west side of McKenzie Inlet caused top-kill and tree mortality.

1972 No budworm activity was noted during the summer, but larval counts were up at several locations throughout the Tongass National Forest (Baker and Curtis 1972). Hemlock sawflies defoliated approximately 23,000 acres of hemlock at various locations from Etolin Island south to Moira Sound, the majority of which occurred on Revillagigedo Island and the east side of Prince of Wales Island. Defoliation in the Ward Creek drainage near Ketchikan caused both hemlock and spruce mortality in addition to top-kill.

1973 Budworm populations increased across the southern Tongass National Forest. Budworm feeding was noted on the same 13,000 acres where sawflies were credited with causing medium to heavy defoliation (Baker and Laurent 1973). This sawfly activity was located primarily on the east side of Prince of Wales Island and on

(1973 continued)
Revillagigedo Island. Approximately 1100 acres of defoliation in the Ward Creek drainage, a popular recreational area, caused public concern.

1974 Moderate to heavy defoliation of hemlock and some spruce by the black-headed budworm was identified on approximately 11,500 acres on the Tongass National Forest. This activity was confined primarily to forests south of Frederick Sound, but a notable exception was approximately 2200 acres of defoliation near Fresh Water Lake on Admiralty Island (Baker et. al. 1975). Hemlock sawfly populations were at low levels and caused little noticeable damage.

1975 Black-headed budworm defoliation and populations were less than in 1974. Population declines were inpart due to cool summer temperatures and possible increases in parasites and disease organisms (Hostetler et. al. 1976). A total of 5400 acres of defoliation was noted on Lincoln and Sullivan Islands in Lynn Canal near Juneau. For the second consecutive year, hemlock sawflies caused no significant damage in Southeast Alaska.

1976 Black-headed budworm caused little noticeable defoliation. Populations measured in 1975 and 1976 appeared to be at their lowest levels since 1971 (Rush et. al. 1977). Black-headed budworm larvae were found feeding on white spruce within the Bonanza Creek Experimental Forest (west of Fairbanks), but their impact was insignificant (Werner 1992). Hemlock sawfly populations were equally low and caused no appreciable damage.

1977 Both black-headed budworm and hemlock sawfly populations remained at endemic levels and nethier caused noticeable defoliation (Anon. 1979a).

1978 Budworm and sawfly populations remained low and did not cause detectable damage (Anon. 1979b).

1979 Budworm and sawfly populations in Southeast Alaska were again endemic. Visible hemlock defoliation by budworm, totalling approximately 250 acres, occurred on Heceta Island west of Prince of Wales (Anon. 1980). Approximately 3000 acres of white spruce were heavily defoliated by the black-headed budworm 50 km northwest of Dillingham between Lake Kulik and Grant Lake. Black-headed budworm larvae were found feeding on white spruce within the Bonanza Creek Experimental Forest (west of Fairbanks), but their impact was insignificant (Werner 1992).

1980 Budworm and sawfly populations remained at endemic levels. No budworm defoliation was noted on Heceta Island (Anon. 1981) or near Dillingham.

1981 Budworm and sawfly populations were again endemic across Southeast Alaska (Anon. 1983a).

1982 Budworm and sawfly populations were endemic in Southeast Alaska, but, sawflies did defoliate approximately 500 acres of hemlock on the southern end of Prince of Wales Island (Anon. 1983a). For the first time in 10 years, black-headed budworm defoliated hemlock in the Prince William Sound area. The defoliation was apparent across approximately 1250 acres near Port Gravina.

1983 The black-headed budworm outbreak continued in the Prince William Sound area. Hemlock defoliation totalling approximately 16,700 acres was noted near Ports Gravina and Fidalgo (Anon. 1983b). Defoliation occurred on young and old growth western hemlock and on some Sitka spruce. Favorable winter and spring weather conditions were cited in association with the population increase. No defoliation by budworm was detected in Southeast Alaska.

Contrary to the budworm, hemlock sawfly activity increased in Southeast Alaska. Approximately 61,800 acres of hemlock were defoliated at various locations, primarily south of Frederick Sound (Anon. 1983b). Defoliation was most severe on southern Prince of Wales, but significant damage was also noted on Admiralty, Chichagof, Kuiu and Dall Islands. Defoliation was reported as far north as Spasski Point and the town of Hoonah (northeastern Chichagof Island).

1984 Budworm populations near Ports Gravina and Fidalgo (Prince William Sound) declined from 1983, though approximately 8800 acres of defoliation was detected (Anon. 1985a). Due to three consecutive years of defoliation, some hemlock top-kill was apparent. Budworm numbers in Southeast Alaska were even lower than the already endemic levels of 1983.

Hemlock sawfly populations continued to expand and defoliation in Southeast Alaska totalled approximately 68,800 acres (Anon. 1985a). The majority of the damage was located on the southern half of Prince of Wales Island. The most severe defoliation occurred near Salmon Lake and Skowl Arm on Prince of Wales and at View Cove on Dall Island.

1985 Low numbers of black-headed budworm were sampled at various locations throughout Southeast Alaska and no significant defoliation was observed (Anon. 1985b). Hemlock sawfly caused significant defoliation of forests south of Frederick Sound, though it was substantially less than recent years. Approximately 28,000 acres of hemlock showed signs of active defoliation. Approximately half of the defoliation was noted as light, however scattered to heavy top-kill and tree mortality did occur on about 7800 acres. Areas of hemlock top-kill and mortality, located primarily on northern Dall Island from Breezy Bay to View Cove, were the same locations that experienced heavy sawfly defoliation in 1983 (Anon. 1985b). Of the many areas in 1983 that showed light to moderate defoliation, several had new growth and appeared to be fully recovered. Continued sawfly activity was predicted for all of the Tongass, especially in the central and northern portions.

1986 Black-headed budworm was again found in very low numbers, but an 80 acre stand of young-growth spruce and hemlock was defoliated on northern Tuxekan Island (Anon. 1986). Hemlock sawfly activity continued to decline, but defoliation was detected on approximately 18,000 acres. Scattered to heavy top-kill was noted on approximately 9880 acres of hemlock defoliated in previous years, predominantly in 1983 (Anon. 1986). Old top-kill and tree mortality were most obvious on Dall Island between View Cove and Breezy Bay and in Skowl Arm (Prince of Wales) between Polk and McKenzie Inlets. Larval sampling indicated a decline of approximately 33 percent from 1985 levels. Sawfly activity was predicted to continue at reduced levels in 1987.

1987 The black-headed budworm did not cause notable defoliation in 1987. However, its impact from 1986 was significant because a single year's defoliation caused top-kill in the young-growth stand on Tuxekan Island (Anon. 1987).

Hemlock sawfly populations declined for the third consecutive year. Light to moderate defoliation occurred on approximately 1890 acres, located primarily from southern Etolin Island to southern Prince of Wales Island (Anon. 1987). Previously undetected hemlock top-kill and mortality totalling approximately 1100 acres was noted on Prince of Wales Island (near Little Ratz Harbor, eastern Kasaan Peninsula from Tolstoi Bay to Windfall Harbor, Upper Hetta Inlet, and Moira Sound to Cholmondeley Sound). In total, approximately 11,000 acres had hemlock top-kill or mortality due to repeated defoliation by sawflies (Anon. 1987).

1988 Budworm populations in the Prince William Sound area exploded and caused defoliation across approximately 145,000 acres (Anon. 1988). Budworm populations in that area had been at endemic levels since 1985. Defoliation was most significant at Ports Fidalgo and Gravina, the southwest end of Hawkins Island, the northwest and southwest sides of Montague Island, all of Green, Knight, and Perry Islands and portions of Latouche, Ekington, Evans, Chenega, Naked, Glacier and Culross Islands (Anon. 1988). This sudden budworm activity was most likely the result of warm temperatures during moth dispersal and oviposition in August and September of 1987.

Neither black-headed budworm or hemlock sawfly caused noticeable defoliation in Southeast Alaska. Approximately 3000 acres of additional hemlock top-kill and mortality (from sawfly activity between 1983 and 1985) was identified (Anon. 1988). This damage occurred primarily on Revillagigedo and Prince of Wales Islands and on Cleveland Peninsula. Hemlock sawfly activity during the mid-1980's caused hemlock top-kill and mortality on over 14,000 acres across Southeast Alaska (Anon. 1988).

1989 Budworm populations in the Prince William Sound area declined significantly. Defoliation was detected across 18,993 acres and some top-kill was noted on both Sitka spruce and western hemlock (Anon. 1989). Defoliation occurred from Ester

(1989 continued)
Island to Port Gravina; Smith, Green, Knight, Perry and Naked Islands had visible damage. Budworm and sawfly populations were low in Southeast Alaska and no appreciable defoliation was detected.

1990 An unexpected increase in budworm activity occurred in Prince William Sound. Defoliation was detected on almost 40,000 acres. Damage was most severe at Ports Fidalgo and Gravina, the northwest side of Hinchinbrook Island, the southern end of Ester Island, the outer edge of Knight Island and parts of Montague, Latouche, Ekington, Evans, Chenega, Naked, Glacier, Culross and Green Islands (Anon. 1990). Warm temperatures in spring and late summer were cited as reasons for the increased activity.

In Southeast Alaska, light defoliation from budworm was observed on Revillagigedo Island and at the head of Bradfield Canal (Anon. 1990). Budworm and sawfly populations across Southeast Alaska were noted as low.

1991 Budworm activity in Prince William Sound declined significantly. Defoliation was detected on 7491 acres. Defoliation was most severe between Tatitlek and Cordova (4126 acres) and along the shore of Ester Island (623 acres) east-northeast of Whittier. As in the previous two years, defoliation was limited to trees along shoreline areas.

Approximately 5900 acres of light defoliation by budworm was detected in Southeast Alaska, primarily on the northern half of the Tongass National Forest. Damage was noted on Shelter Island, on the north side of the Taku River, on southwest Admiralty Island and at Windam and Farragut Bays. Farther south, defoliation was noted on Baker Island (west of Prince of Wales) and along the south arm of Moira Sound on Prince of Wales Island. Hemlock sawfly damage totalling approximately 900 acres was detected near Port Bazan on the west side of Dall Island (Anon. 1992).

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APPENDIX A

Black-Headed Budworm, *Acleris gloverana*

Hosts: Western hemlock (preferred), Sitka and white spruce.

Damage: Larvae feed within buds and on current year's foliage and can cause top-kill, growth loss and sometimes death of the host. Mature larvae are capable of feeding on both new and old foliage. Larvae are wasteful feeders and do not usually consume entire needles (Schmiege and Crosby 1970). Defoliation becomes apparent in June and July as partially eaten needles dry and turn red, giving the crowns of host trees a red or brown appearance.

Distribution: Southeast Alaska, Prince William's Sound and southwestern Alaska.

Description: Adults are small, brown and/or grey moths, with variable brown, black, orange, and white markings on their wings. Moths have a wingspread of approximately 3/4 inch. Immature larvae appear yellow-green and become completely green as they mature. Larvae have a black head during the first four development stages (instars) that eventually appears tan-orange in the last stage . Mature larvae vary in length, but are approximately 1.7 cm long. Pupae are brown and normally have a green hue. Budworm eggs are yellow and flattened, and are approximately 1 mm long.

Biology: Black-headed budworms spend the winter in the egg stage on host foliage. Eggs hatch in June and first instar larvae begin feeding. Feeding typically begins within unopened buds and continues later on elongating shoots.

Individual mature larvae tie live and cut needles together to form a pupal shelter. Adults emerge in late August through October. Adult moths mate and females lay their eggs singly on the underside of host needles. Female moths lay approximately 80 eggs.

Budworm populations in Southeast Alaska have experienced sporadic explosions, followed a few years later by rapid declines. These increases and declines have often been unexplained. However, sixteen species of black-headed budworm parasites and predators have been identified in Alaska. In addition, adverse weather also appears to be an important controlling factor of budworm populations in coastal Southeast Alaska.

(Appendix A, Black-headed Budworm continued)

To date, only pilot suppression projects have been tested against black-headed budworm populations in Alaska. This is due inpart to the cyclic nature of these populations. Future investigations will include evaluation of budworm impacts on young-growth stands.

Hemlock Sawfly, *Neodiprion tsugae*

Host: Western hemlock.

Damage: Larvae feed on old foliage resulting in growth reduction and possible top-kill.

Distribution: Throughout Southeast Alaska. Sawflies are more numerous and outbreaks tend to be of longer duration in southern Southeast Alaska. Widespread damage has typically occurred south of Frederick Sound, especially along Clarence Strait, the warmest area in Southeast Alaska (Holsten et. al. 1985) .

Description: Adults are small, thick-waisted wasps approximately 5-8 mm long. Females are larger than males, are olive green in color, and have serrated attennae. Males are black and have plumed antennae. Young larvae are almost completely black, but later instars turn dark green. Full grown larvae develop a dark longitudinal stripe along each side. Larvae in all stages of development have black head capsules. Mature larvae are 15-20 mm long (Hard et. al. 1976). Sawflies pupate in brown, capsule-like cocoons that are approximately 7 mm long.

Biology: Adults emerge in September and October. Sawflies typically overwinter as eggs on host foliage, with rare individuals spending the winter as pupae in forest litter. Females cut notches in the edge of hemlock needles where they deposit single eggs. Each female lays approximately 70 eggs. Eggs hatch in June and larvae feed gregariously on old foliage. Sawfly larvae are unable to complete their development cycle by feeding solely on new foliage. Pupation takes place in cocoons on host foliage or in forest litter, usually during August and September.

Most sawfly outbreaks do not cause tree mortality, but some trees are top-killed and radial growth may be reduced. Sawflies cause the greatest amount of damage when found simultaneously with black-headed budworm.

(Appendix A, Hemlock Sawfly continued)

Natural controls have reduced epidemic sawfly populations within a few years. Warm and wet summers help reduce populations by favoring conditions for fungi that are known to infect immature forms of the sawfly. In addition, low summer temperatures help reduce sawfly populations. Cooler temperatures delay sawfly development and reduce opportunities for successful oviposition. Depletion of host foliage is likewise known to impact sawfly populations resulting in starvation and poor nutrition of actively feeding larvae (Holsten et. al. 1985).